

$\Upsilon(4S)$
or $\Upsilon(10580)$

$I^G(J^{PC}) = 0^-(1^{--})$

$\Upsilon(4S)$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
10.5794 ± 0.0012 OUR AVERAGE			
10.5793 $\pm 0.0004 \pm 0.0012$	AUBERT 05Q	BABR	$e^+ e^- \rightarrow$ hadrons
10.5800 ± 0.0035	¹ BEBEK 87	CLEO	$e^+ e^- \rightarrow$ hadrons
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
10.5774 ± 0.0010	² LOVELOCK 85	CUSB	$e^+ e^- \rightarrow$ hadrons
¹ Reanalysis of BESSON 85. ² No systematic error given.			

$\Upsilon(4S)$ WIDTH

VALUE (MeV)	DOCUMENT ID	TECN	COMMENT
20.5 ± 2.5 OUR AVERAGE			
20.7 $\pm 1.6 \pm 2.5$	AUBERT 05Q	BABR	$e^+ e^- \rightarrow$ hadrons
20 $\pm 2 \pm 4$	BESSON 85	CLEO	$e^+ e^- \rightarrow$ hadrons
$\bullet \bullet \bullet$ We do not use the following data for averages, fits, limits, etc. $\bullet \bullet \bullet$			
25 ± 2.5	LOVELOCK 85	CUSB	$e^+ e^- \rightarrow$ hadrons

$\Upsilon(4S)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Confidence level
$\Gamma_1 B\bar{B}$	> 96 %	95%
$\Gamma_2 B^+ B^-$	(50.9 ± 0.7) %	
$\Gamma_3 D_s^+$ anything + c.c.	(17.8 ± 2.6) %	
$\Gamma_4 B^0 \bar{B}^0$	(49.1 ± 0.7) %	
Γ_5 non- $B\bar{B}$	< 4 %	95%
$\Gamma_6 e^+ e^-$	(1.57 ± 0.08) $\times 10^{-5}$	
$\Gamma_7 J/\psi(1S)$ anything	< 1.9 $\times 10^{-4}$	95%
$\Gamma_8 D^{*+}$ anything + c.c.	< 7.4 %	90%
$\Gamma_9 \phi$ anything	(7.1 ± 0.6) %	
$\Gamma_{10} \phi\eta$	< 2.5 $\times 10^{-6}$	90%
$\Gamma_{11} \Upsilon(1S)$ anything	< 4 $\times 10^{-3}$	90%
$\Gamma_{12} \Upsilon(1S)\pi^+\pi^-$	(9.0 ± 1.5) $\times 10^{-5}$	
$\Gamma_{13} \Upsilon(2S)\pi^+\pi^-$	(8.8 ± 1.9) $\times 10^{-5}$	
$\Gamma_{14} \overline{d}$ anything	< 1.3 $\times 10^{-5}$	90%

$\Upsilon(4S)$ PARTIAL WIDTHS

$\Gamma(e^+ e^-)$

VALUE (keV)

0.272±0.029 OUR AVERAGE

0.321±0.017±0.029

0.28 ±0.05 ±0.01

0.192±0.007±0.038

0.283±0.037

DOCUMENT ID

TECN

COMMENT

Γ_6

Error includes scale factor of 1.5. See the ideogram below.

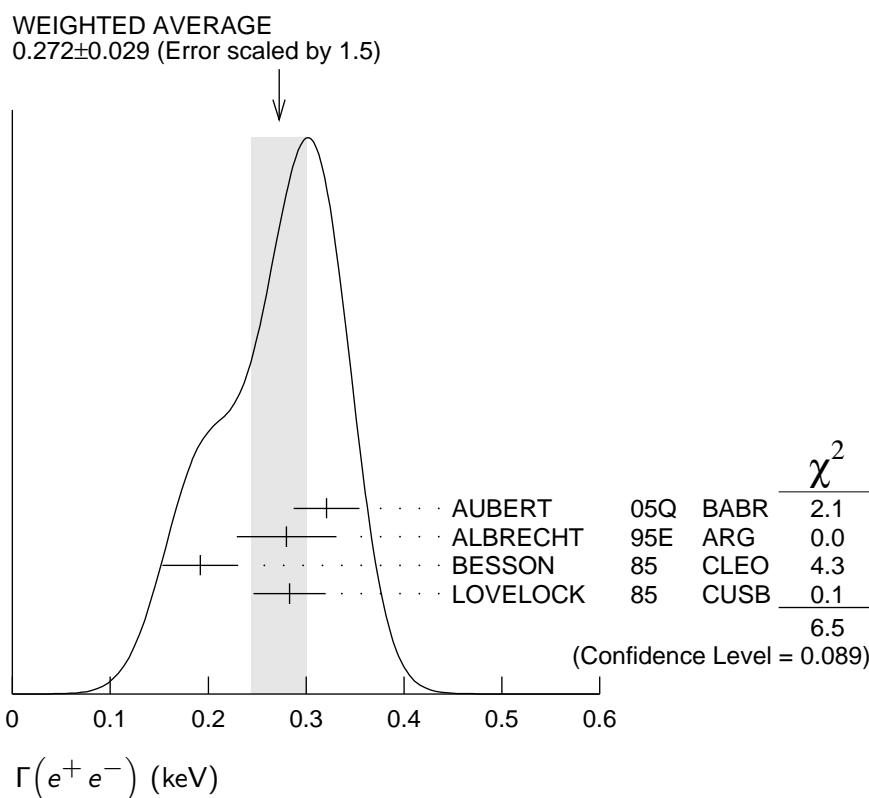
AUBERT 05Q BABR $e^+ e^- \rightarrow$ hadrons

³ ALBRECHT 95E ARG $e^+ e^- \rightarrow$ hadrons

BESSON 85 CLEO $e^+ e^- \rightarrow$ hadrons

LOVELOCK 85 CUSB $e^+ e^- \rightarrow$ hadrons

³ Using LEYAOUANC 77 parametrization of $\Gamma(s)$.



$\Upsilon(4S)$ BRANCHING RATIOS

$B\bar{B}$ DECAYS

The ratio of branching fraction to charged and neutral B mesons is often derived assuming isospin invariance in the decays, and relies on the knowledge of the B^+/B^0 lifetime ratio. "OUR EVALUATION" is obtained based on averages of rescaled data listed below. The average and rescaling were performed by the Heavy Flavor Averaging Group (HFAG) and are described at <http://www.slac.stanford.edu/xorg/hfag/>. The averaging/rescaling procedure takes into account the common dependence of the measurement on the value of the lifetime ratio.

$\Gamma(B^+ B^-)/\Gamma_{\text{total}}$

VALUE DOCUMENT ID

0.509±0.007 OUR EVALUATION Assuming $B(\Upsilon(4S) \rightarrow B\bar{B}) = 1$

Γ_2/Γ

$\Gamma(D_s^+ \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}$

VALUE

0.178±0.021±0.016

DOCUMENT ID

⁴ ARTUSO

TECN

05B

COMMENT

$e^+ e^- \rightarrow D_X X$

⁴ ARTUSO 05B reports $[B(\Upsilon(4S) \rightarrow D_s^+ \text{ anything} + \text{c.c.}) \times B(D_s^+ \rightarrow \phi\pi^+)] = (8.0 \pm 0.2 \pm 0.9) \times 10^{-3}$. We divide by our best value $B(D_s^+ \rightarrow \phi\pi^+) = (4.5 \pm 0.4) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

Γ_3/Γ

$\Gamma(B^0 \bar{B}^0)/\Gamma_{\text{total}}$

Γ_4/Γ

VALUE

DOCUMENT ID

TECN

COMMENT

0.491±0.007 OUR EVALUATION Assuming $B(\Upsilon(4S) \rightarrow B\bar{B}) = 1$

• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.487 \pm 0.010 \pm 0.008$

⁵ AUBERT,B 05H BABR $\Upsilon(4S) \rightarrow \bar{B}B \rightarrow D^* \ell \nu_\ell$

⁵ Direct measurement. This value is averaged with the value extracted from the $\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$ measurements.

$\Gamma(B^+ B^-)/\Gamma(B^0 \bar{B}^0)$

Γ_2/Γ_4

VALUE

DOCUMENT ID

TECN

COMMENT

1.037±0.029 OUR EVALUATION

$1.006 \pm 0.036 \pm 0.031$

⁶ AUBERT 04F BABR $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K$

$1.01 \pm 0.03 \pm 0.09$

⁶ HASTINGS 03 BELL $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow \text{dileptons}$

$1.058 \pm 0.084 \pm 0.136$

⁷ ATHAR 02 CLEO $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow D^* \ell \nu$

$1.10 \pm 0.06 \pm 0.05$

⁸ AUBERT 02 BABR $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow (c\bar{c})K^*$

$1.04 \pm 0.07 \pm 0.04$

⁹ ALEXANDER 01 CLEO $\Upsilon(4S) \rightarrow B\bar{B} \rightarrow J/\psi K^*$

⁶ HASTINGS 03 and AUBERT 04F assume $\tau(B^+)/\tau(B^0) = 1.083 \pm 0.017$.

⁷ ATHAR 02 assumes $\tau(B^+)/\tau(B^0) = 1.074 \pm 0.028$. Supersedes BARISH 95.

⁸ AUBERT 02 assumes $\tau(B^+)/\tau(B^0) = 1.062 \pm 0.029$.

⁹ ALEXANDER 01 assumes $\tau(B^+)/\tau(B^0) = 1.066 \pm 0.024$.

— non- $B\bar{B}$ DECAYS —

$\Gamma(\text{non-}B\bar{B})/\Gamma_{\text{total}}$

Γ_5/Γ

VALUE

CL%

<0.04

95

DOCUMENT ID

TECN

COMMENT

$e^+ e^-$

$\Gamma(e^+ e^-)/\Gamma_{\text{total}}$

Γ_6/Γ

VALUE (units 10^{-5})

DOCUMENT ID

TECN

COMMENT

1.57±0.08 OUR AVERAGE

$1.55 \pm 0.04 \pm 0.07$

AUBERT 05Q BABR

$e^+ e^- \rightarrow \text{hadrons}$

$2.77 \pm 0.50 \pm 0.49$

¹⁰ ALBRECHT 95E ARG

$e^+ e^- \rightarrow \text{hadrons}$

¹⁰ Using LEYAOUANC 77 parametrization of $\Gamma(s)$.

$\Gamma(J/\psi(1S) \text{ anything})/\Gamma_{\text{total}}$

Γ_7/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<1.9	95	11 ABE	02D BELL	$e^+ e^- \rightarrow J/\psi X \rightarrow \ell^+ \ell^- X$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<4.7	90	11 AUBERT	01C BABR	$e^+ e^- \rightarrow J/\psi X \rightarrow \ell^+ \ell^- X$
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11 Uses $B(J/\psi \rightarrow e^+ e^-) = 0.0593 \pm 0.0010$ and $B(J/\psi \rightarrow \mu^+ \mu^-) = 0.0588 \pm 0.0010$.

$\Gamma(D^{*+} \text{ anything} + \text{c.c.})/\Gamma_{\text{total}}$

Γ_8/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.074	90	12 ALEXANDER	90C CLEO	$e^+ e^-$

12 For $x > 0.473$.

$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$

Γ_9/Γ

VALUE (units 10^{-2})	CL%	DOCUMENT ID	TECN	COMMENT
7.1 ± 0.1 ± 0.6		HUANG	07 CLEO	$\gamma(4S) \rightarrow \phi X$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.23	90	13 ALEXANDER	90C CLEO	$e^+ e^-$
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13 For $x > 0.52$.

$\Gamma(\phi\eta)/\Gamma_{\text{total}}$

Γ_{10}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
<2.5	90	AUBERT,BE	06F BABR	$e^+ e^- \rightarrow \phi\eta$

$\Gamma(\gamma(1S) \text{ anything})/\Gamma_{\text{total}}$

Γ_{11}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.004	90	ALEXANDER	90C CLEO	$e^+ e^-$

$\Gamma(\gamma(1S)\pi^+\pi^-)/\Gamma_{\text{total}}$

Γ_{12}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.90 ± 0.15 ± 0.02		167 ± 19	14 AUBERT	06R BABR	$e^+ e^- \rightarrow \pi^+ \pi^- \mu^+ \mu^-$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<1.2	90	GLENN	99 CLE2	$e^+ e^-$
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14 AUBERT 06R reports $[B(\gamma(4S) \rightarrow \gamma(1S)\pi^+\pi^-) \times B(\gamma(1S) \rightarrow \mu^+\mu^-)] = (2.23 \pm 0.25 \pm 0.27) \times 10^{-6}$. We divide by our best value $B(\gamma(1S) \rightarrow \mu^+\mu^-) = (2.48 \pm 0.05) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\gamma(2S)\pi^+\pi^-)/\Gamma_{\text{total}}$

Γ_{13}/Γ

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.88 ± 0.17 ± 0.08		97 ± 15	15 AUBERT	06R BABR	$e^+ e^- \rightarrow \pi^+ \pi^- \mu^+ \mu^-$

• • • We do not use the following data for averages, fits, limits, etc. • • •

<3.9	90	GLENN	99 CLE2	$e^+ e^-$
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15 AUBERT 06R reports $[B(\gamma(4S) \rightarrow \gamma(2S)\pi^+\pi^-) \times B(\gamma(2S) \rightarrow \mu^+\mu^-)] = (1.69 \pm 0.26 \pm 0.20) \times 10^{-6}$. We divide by our best value $B(\gamma(2S) \rightarrow \mu^+\mu^-) = (1.93 \pm 0.17) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\bar{d} \text{ anything})/\Gamma_{\text{total}}$		Γ_{14}/Γ		
VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<1.3	90	ASNER	07	CLEO $e^+ e^- \rightarrow \bar{d} X$

T(4S) REFERENCES

ASNER	07	PR D75 012009	D.M. Asner <i>et al.</i>	(CLEO Collab.)
HUANG	07	PR D75 012002	G.S. Huang <i>et al.</i>	(CLEO Collab.)
AUBERT	06R	PRL 96 232001	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT,BE	06F	PR D74 111103R	B. Aubert <i>et al.</i>	(BABAR Collab.)
ARTUSO	05B	PRL 95 261801	M. Artuso <i>et al.</i>	(CLEO Collab.)
AUBERT	05Q	PR D72 032005	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT,B	05H	PRL 95 042001	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	04F	PR D69 071101	B. Aubert <i>et al.</i>	(BABAR Collab.)
HASTINGS	03	PR D67 052004	N.C. Hastings <i>et al.</i>	(BELLE Collab.)
ABE	02D	PRL 88 052001	K. Abe <i>et al.</i>	(BELLE Collab.)
ATHAR	02	PR D66 052003	S.B. Athar <i>et al.</i>	(CLEO Collab.)
AUBERT	02	PR D65 032001	B. Aubert <i>et al.</i>	(BaBar Collab.)
ALEXANDER	01	PRL 86 2737	J.P. Alexander <i>et al.</i>	(CLEO Collab.)
AUBERT	01C	PRL 87 162002	B. Aubert <i>et al.</i>	(BaBar Collab.)
GLENN	99	PR D59 052003	S. Glenn <i>et al.</i>	
BARISH	96B	PRL 76 1570	B.C. Barish <i>et al.</i>	(CLEO Collab.)
ALBRECHT	95E	ZPHY C65 619	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
BARISH	95	PR D51 1014	B.C. Barish <i>et al.</i>	(CLEO Collab.)
ALEXANDER	90C	PRL 64 2226	J. Alexander <i>et al.</i>	(CLEO Collab.)
BEBEK	87	PR D36 1289	C. Bebek <i>et al.</i>	(CLEO Collab.)
BESSON	85	PRL 54 381	D. Besson <i>et al.</i>	(CLEO Collab.)
LOVELOCK	85	PRL 54 377	D.M.J. Lovelock <i>et al.</i>	(CUSB Collab.)
LEYAOUANC	77	PL B71 397	A. Le Yaouanc <i>et al.</i>	(ORsay)

OTHER RELATED PAPERS

VOLOSHIN	05A	PAN 68 771 Translated from YAF 68 804.	M.B. Voloshin	
ABE	01J	PR D64 072001	K. Abe <i>et al.</i>	(BELLE Collab.)
HENDERSON	92	PR D45 2212	S. Henderson <i>et al.</i>	(CLEO Collab.)
ANDREWS	80B	PRL 45 219	D. Andrews <i>et al.</i>	(CLEO Collab.)
FINOCCHI...	80	PRL 45 222	G. Finocchiaro <i>et al.</i>	(CUSB Collab.)